Assignment of measurable costs and benefits to wildlife biodiversity conservation projects

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Abstract: Success of biodiversity conservation projects is determined by a suite of biological and economic factors. Donor and public understanding of the economic factors is becoming increasingly central to the longevity of funding for conservation efforts. Unlike typical economic evaluation, many costs and benefits related to conservation efforts are realized in diverse and non-monetary terms. We identify the types of benefits and costs that are assigned to biodiversity projects and examine a number of well-developed and some new techniques that economists use to convert benefits and costs into monetary values so that they may be compared in a common metric. Commonly costs are more readily identified than benefits, with financial project costs the most frequently reported and to a much lesser extent, opportunity and damage costs. Additionally, costs have been recognized as being largely spatially dependent while benefits have not received this same distinction. Opportunity costs have been largely absent from many conservation project analyses likely overstating the returns to project investment. Most current evaluation methodologies focus mainly on costs and rely primarily on cost-effectiveness analysis more commonly than cost-benefit analysis, resulting from the difficultly in measuring benefits. Movement toward the measurement of the benefits and costs of conservation efforts is urged throughout most of the literature. Improvements to the determination of conservation project returns can be made through the incorporation of spatial considerations of economic impacts which includes regional economic analysis.

Introduction

Demonstration of the returns from biological conservation efforts has become a requirement of many funded projects designed to protect and promote wildlife populations of concern. With annual estimates of conservation expenditures in the billions of dollars, conservation managers, policy makers and legislators must be able to convey the degree to which resources committed to conservation projects promote success (Honey-Roses 2011, Kapos et al. 2008, Ferraro & Pattanayak 2006, Halpern et al. 2006, Waetzold et al. 2006, James et al. 1999). Even international funding agencies like the United Nations are requiring that countries demonstrate that their conservation programs achieved effective levels of protection to receive retrospective monetary compensation for project efforts (Honey-Roses 2011, Combes Motel et al. 2009). Evaluating conservation project cost-effectiveness is to measure the improvement in biological outcome attributable to the project, per dollar spent (Busch and Cullen 2009). Assessing the success of conservation projects is difficult for a myriad of reasons including a lack of resources or motivation for project evaluation, unclear project objectives, unavailable data and achievement of objectives that are outside project timelines (Kapos et al. 2008). Research related to the ex-post measurement of the cost-effectiveness of wildlife conservation projects is limited and few analyses provide guidelines as to how to examine conservation projects (Kapos et al. 2008).

Methods to evaluate the economic efficiency of wildlife conservation projects usually involve several trade-offs. Lack of data availability or inability to quantify benefits may drive the type of methodology used. However, the ability to convey to donors and other stakeholders the benefits of the project per dollar spent has become one of the most crucial objectives of this type of analysis. The most common methodology used is cost-effectiveness analysis (CEA) and to a much lesser extent cost-benefit analysis (CBA). Improvements and innovations to these methodologies have led to the development of other methods including: cost-utility analysis (CUA), threat reduction assessment (TRA) and conservation output protection years (COPY).

Cost-benefit analysis or benefit-cost analysis can be used when the productive units of the conservation project can be assigned a monetary value (Christie et al. 2011, Naidoo and Ricketts 2006, Gutman 2002, Engeman et al. 2002a, 2003). For example, if the goal of the project is to increase the number of birds that have been determined to have a monetary social value, then this value can be used to determine if the costs expended on the project were justified in terms of the total benefits (total value of birds produced or protected)(Engeman et al. 2002a, 2003). Benefit-cost ratios are calculated when the value of units produced is divided by the costs to provide a ratio of monetary value of benefits for every unit of costs. Since benefits are calculated in the same units as costs all results are expressed in monetary terms.

Most commonly CEA and CUA are used when analysts can quantify the impacts of the conservation project but cannot monetize them (Laycock et al. 2009, Naidoo et al. 2006, Boardman et al. 1996). For example, if a wildlife conservation project can measure the increase in the number of desirable units (e.g., nests, eggs, juveniles, adults, etc.) produced through different management efforts and has cost information for each management effort, but is unable to value the units then CEA is most appropriate. Economic efficiency is thereby determined by the methodology that produces the greatest return at the least cost (Laycock et al. 2011, Caudell et al. 2010, Engeman et al. 2002a, 2003, Cullen et al. 2001, 2005). Like CEA, CUA is another popular alternative to CBA that is widely used by health economists as a measure of the improvements to health status (Laycock et al. 2011, Boardman et al. 1996). These types of analyses also lend themselves to more sophisticated types of statistical examination such as regression and multi-regression analysis to determine the influence of different factors that may play a role in the effectiveness or cost-effectiveness of alternative management efforts (Laycock et al. 2011, 2009, Busch and Cullen 2009, Shwiff et al. 2005).

Salafsky and Margoluis (1999) developed TRA to assess conservation success by using a reduction in the threats to biodiversity as a measure. In an effort to provide a similar conservation metric to Quality-Adjusted Life Years (QALY), COPY was developed to capture the improvement in conservation status after the implementation of a conservation program (Laycock et al. 2011, Cullen et al. 2005a, Hughey et al. 2003, Cullen et al. 2001, Cullen et al. 1999). Integrating costs into both the TRA and COPY measures allows for the calculation of cost-TRA and cost-COPY ratios to provide information on the cost per unit of threat reduction or cost per increase in conservation output protection per year (Laycock et al. 2011). Improvements in conservation status by examining COPY and TRA are relatively new to project evaluation and do not explicitly require the calculation of benefits or costs in the same manner as CBA, CEA and CUA and only CBA requires the explicit monetary calculation of benefits.

Determining the benefits of biological conservation programs can be extremely challenging and often the determination of costs is significantly easier than benefits. Benefits are usually derived from the increased production or loss avoided of the species that is the subject of the conservation program (Kapos et al. 2008). Likely these species do not have any standard market value, and even when there is some commercial value, it typically understates the full social value of the species. Therefore, values must be determined by other methods such as contingent valuation (CVM), travel costs (TCM) choice modeling (CM) or a range of other methodologies. In addition to calculating the primary benefits associated with the conservation of a particular species there may be secondary benefits that accrue to the economy as a result of increased consumptive (e.g., hunting or fishing tourism) or non-consumptive (e.g., viewing tourism) uses of the species.

Central to all methodologies used in economic evaluations of biological conservation projects is the determination of costs. We provide examples of project cost determinations as well as some methods to assess benefits. Additionally, we highlight some of the shortcomings of each methodology and make recommendations on how to improve project analysis to achieve greater funding success for future projects.

Determining Project Costs

Maximization of conservation project objectives within the context of cost limitations should always be an implicit project objective. Studies have outlined a myriad of costs associated with the implementation of conservation projects (Armsworth et al 2011, Schneider et al 2011, Adams et al 2010, Jankte and Schneider 2009, Naidoo et al 2009). Naidoo et al, (2006), provides a comprehensive list of costs associated with conservation programs including acquisition costs, management costs, transaction costs, damage costs and opportunity costs. Most costs have spatial explicit considerations and can vary depending on the size and location of the conservation project parcel while other costs may be fixed (Armsworth et al 2011, Schneider et al 2011, Jankte and Schneider 2009, Naidoo et al 2009).

Acquisition, management and transaction costs can be referred to as the financial costs associated with project implementation and typically involve land purchase/lease, land management, equipment, labor, supplies, planning, negotiating and other related costs crucial to project completion and management (Figure 1). Damage costs can also be referred to as spillover or indirect costs in that they arise from the conservation project but are a burden to those outside of the project. Damage costs are usually absent from efficiency analyses because of a lack of data collected on impacts to humans, wildlife and habitat adjacent to conservation project land. This could result from a lack of resources available to capture data as well as an inability both spatially and temporally to identify individuals that have been impacted by the project.

Defining opportunity costs in a conservation project framework usually arises from the designation of land into conservation status. Measured in this way, opportunity costs arise from reduced agricultural production, lost recreational opportunities, loss of competing species or habitat, increased human conflicts and other forgone uses of the conserved land (Armsworth et al. 2011, Schneider et al. 2011, Adams et al. 2010, Jankte and Schneider 2009, Naidoo et al. 2009, Naidoo and Adamowicz 2006, Naidoo and Ricketts 2006). For example, conservation projects may decrease the amount of agricultural commodities grown or restrict access of tourists who will no longer spend their money in the region and these forgone values must be factored as a cost.

Capturing the opportunity costs associated with conservation projects is difficult for some of the same reasons as capturing the benefits of these projects. For example, if a conservation project involves restricting access of tourists to a particular area then the value of that area to the tourists must be valued through a variety of methods described in the benefits section. Similarly, if competing habitat (e.g., other conservation projects, bioenergy plantations and intensively managed forests) or species must be removed the habitat or species must be monetized to be included in the cost calculation (Jantke and Schneider 2009). Valuing the loss of agricultural production is possible given a variety of techniques including direct market valuation and using a regional economic model.

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The financial (e.g., acquisition, management and transaction) costs of conservation projects typically form the framework for the cost portion of economic analyses examining the efficiency of resources allocated to conservation projects. These costs can be obtained by keeping good financial records of all aspects of expenditures related to the project. Studies indicate that site area is the most important driver of not only acquisition costs but also management and opportunity costs (Armsworth et al. 2011, Naidoo and Ricketts 2006). Additionally, management costs have demonstrated economies of scale in relation to site area which have implications for economic efficiency in terms of site selection (Armsworth et al. 2011). Research indicates that land use surrounding a particular site area can have varying levels of cost impacts depending on the nature of conservation within the site area (Rondinini and Boitani 2007, Naidoo and Ricketts 2006).

A common theme throughout all studies examined was an emphasis on the need to capture the costs of conservation projects since the inclusion of costs in the planning process has been largely absent (Jankte and Schneider 2009, Naidoo et al. 2009, Naidoo and Ricketts 2006, Cullen et al. 2005). Collecting a myriad of costs was supported by most research but acknowledging difficulties it was implied that at a minimum capturing the financial costs associated with a project was sufficient. One study suggests that surrogate costs could be used if enough spatial similarities exist to fill in for a lack of complete accounting of actual costs (Adams et al. 2010).

Assigning Benefit Values

The purpose of wildlife conservation projects is to maintain or increase targeted population size and is commonly measured as the number of animals protected or the increase in number of animals at the end of the project (Kapos et al. 2008). In an economic sense, the measure of efficiency is the value or benefit of production per unit of effort. Conservation efforts rarely involve species that have an observed market value and therefore require techniques that can estimate value in the absence of any market values. Improvements to or conservation of land for targeted wildlife species might also bring improvements to other ecosystem services that are spillover benefits of the project such as increased carbon storage, natural resource harvest, bio-prospecting and others that when applicable should be captured. Valuation of wildlife conservation targeted species can occur through survey methodologies that include the CVM and TCM, and non-survey methodologies that include benefit-transfer, civil penalties and replacement costs (Figure 2). Only CBA requires the calculation of benefits to produce analysis results. Most evaluations of biodiversity conservation projects use a methodology (e.g., CEA, CUA, TRA or COPY) that does not require the calculation of monetized benefits and thus evades the challenges associated with these methods as well as the high costs associated with data collection (Laycock et al. 2009).

Contingent valuation methodology

Contingent valuation methodology (CVM) is a survey-based, stated preference methodology used to estimate use and existence and use values associated with wildlife species (Kotchen and Reiling 1998). This method solicits responses from individuals regarding their willingness to pay (WTP) for increased wildlife populations. Questions are usually designed to solicit responses by describing the outcome of the conservation effort to be valued and then asking individuals if they would pay a certain amount to achieve that outcome. By varying the amount individuals are asked to pay among individual respondents, a social value of the outcome is constructed based on how WTP varies across respondents (Loomis 1990). Several factors can affect the WTP for wildlife conservation including the species usefulness to humans, likeability of species by humans, questionnaire design, information level of respondents and level of economic damage created by the species (Tisdell et al. 2007, Bateman et al. 2002, Nunes and van den Bergh 2001, Brown et al. 1994, 1996, Martin-Lopez et al. 2007a, 2007b).

Criticisms of the CVM method include the hypothetical nature of the questionnaire and the inability to validate responses, causing some to question the usefulness of the method for determining benefits (Champ et al. 2003, Erbele and Hayden 1991). Additionally, it is often viewed that public goods such as wildlife do not lend themselves to valuation in this manner and further, this type of valuation of public resources typically understates the true non-market value (Balmford et al. 2002, Pearce and Moran 1994). In order to overcome some of these potentially serious issues, surveys must be written appropriately to reduce potential uncertainty and biases (Ekstrand and Loomis 1998, Martin-Lopez 2007a, 2007b). Surveys can be expensive to implement and in the case of a conservation program, determining the target audience may be difficult as well. Applications of this type of methodology is increasing in the literature but isstill limited in a wildlife conservation setting (Christie et al. 2009).

Travel cost methodology

The travel cost methodology (TCM) is another survey methodology that uses the costs incurred for travel as a proxy to identify the demand for the recreational activity linked to that species (Kotchen and Reiling 1998). Travel costs become a surrogate for demand for the species. Calculation of consumer surplus is a revealed preference method because it relies on actual behavior. TCM is based on the idea that as some environmental amenity changes, the amount people are willing to pay to use it will change, and that change in willingness to pay is revealed by a change in travel costs. For example, suppose some conservation project improves a fish population in a river relative to other, similar rivers. If this improvement is valuable from a recreation standpoint, the river will be used more intensively and the amount of money people spend using it will increase relative to other rivers. Thus, the increase in travel costs becomes a surrogate for the value of the outcome of the conservation effort.

Criticisms regarding this methodology are mainly founded in the assumptions that are made to define these types of costs, which include substitutes for recreational sites and activities, appropriate valuation of travel time and value of the site. Additionally, applicability of this methodology may be limited in a conservation setting because not only may human access be limited to conservation sites but human awareness or preference toward the species may be limited. If individuals are not willing or able to travel to the conservation site to expend funds then this method confers no value.

Benefit-transfer methodology

The benefit-transfer methodology relies on benefit values derived from CVM and TCM studies that existed in one geographical location but for similar species, which can be transferred to another location. Adjustments to the values can be made by factoring in differences in incomes or prices from one area to the other to more accurately reflect the benefit-transfer value. Naidoo and Ricketts 2006, used this methodology to assign ecosystem service values to assess the benefits of land conservation.

Typical criticismms regarding this method focus on the development and reliability of value estimates since this methodology derives its estimates from usually either CVM or TCM (Smith et al. 2002, Brouwer 2000). Non-methodological issues arise from the belief that wildlife in one area are unique and simply transferring the value associated with a species in one location to the same species in another location does not capture the specific local qualities. While this view may be common, studies have indicated that it is not the case and that average values of species are relatively close regardless of location (Rosenberger and Loomis 2001).

Legislatively designated values

There have been limited uses of civil penalties and other legislatively designated values (Engeman et al. 2002b). Many state wildlife and fisheries management agencies use estimates of economic values based on contributions to the economy by individual game species to derive their monetary values. These values serve as the basis for civil financial penalties for illegal kills resulting from poaching, environmental contamination, or other illegal taking of the animal (Bodenchuk et al. 2002). In the U.S., the federal Migratory Bird Treaty Act and the Endangered Species Act are sources of legislatively designated values for illegal taking of a variety of species of concern.

Engeman et al. (2002a) used a civil penalty value for endangered sea turtles in a CBA of conservation methodologies used to protect the turtles. Under the assumption that an individual is aware of the civil penalty for illegal take with some probability of being caught, but takes the animal anyway, then this value represents a stated WTP value. Criticisms of using legislatively designated values such as civil penalties include that they are set high enough to deter to behavior and as such represent a value higher than an individual's WTP.

Captive breeding costs

Engeman et al. (2003) used cost associated with captive bred Puerto Rican parrots to inform a CBA of predator management for the protection of the birds. Resources were allocated to a facility to breed and raise parrots to be released into the wild. Costs associated with raising a parrot were used as a measure of society's WTP by devoting tax dollars to fund the breeding facility (Engeman et al 2003). One criticism of using captive breeding costs is that these simply represent costs and costs are not necessarily an accurate representation of value (Schuhmann and Schwabe 2002).

Improvements to Current Evaluation Methodologies

Common valuation methodologies as well as criticisms of those methodologies have been highlighted thus far in the manuscript. Improvements to analyses involving conservation programs should include methodology that could engage a broader group of stakeholders by estimating the impacts of conservation beyond primary benefits. Engaging a broader group of stakeholders (e.g., the general public) is vitally important to conservation projects. The implication of stakeholder knowledge about a wildlife species that is the subject of a conservation effort is that individuals are willing to allocate a greater amount of resources to species in which they are familiar (Tisdell and Wilson 2006). In addition, other research indicates that individuals care about the economic impact of wildlife species, which factors into their decision making about wildlife conservation (Martin-Lopez 2008). Regional economic analysis (REA) can offer improvements to current evaluation methodologies.

Regional Economic Analysis

It has been indicated in some conservation economic analyses that the value added or secondary impacts of conservation efforts has not been modeled or accounted for in the determination of benefits or costs (Naidoo and Ricketts 2006). REA allows for the estimation of secondary benefits associated with the conservation of wildlife species in terms of units of measure (e.g., revenue, income and jobs) that are important to the general public. As biological conservation projects increase wildlife populations, the primary benefit of population increases may drive measurable secondary benefits such as increased tourism (both consumptive and non-consumptive) (Duffield 1992, Wilson and Tisdell 2003). Increases in tourism have benefits to the regional economy that can be measured through the use of regional economic models such as IMPLAN (Impact Analysis for Planning, Minnesota IMPLAN® Group, Stillwater MN) and REMI (Regional Economic Modeling Inc.).

These models can estimate incremental regional impacts as economic sectors (e.g., service, manufacturing, and industrial) change activity through multiplier relationships based on input-output tables that measure production linkages in the economy. Multipliers measure the change in the level of regional value added or output and employment associated with a unit change in initial effects (e.g., tourism) of a particular economic sector. For example, conservation programs designed to increase the number of wolves in and around Yellowstone National Park area also increased the amount of tourism to the park (Duffield, 1992). This increase in tourism can be valued as tourist's dollars flow through the economy and support other economic sectors, providing regional jobs and revenue (Shwiff et al. 2010). Modeling impacts in this way can translate conservation efforts into regional (e.g., local, state, province) impacts on revenue and jobs expanding the understanding of conservation to the general public. While these benefits cannot be used in CBAs to determine benefit-cost ratios, they can be an important component of estimating the total impact of conservation efforts and importantly engaging a broader audience by providing implications of conservation efforts to local communities.

Discussion

Economics provides several tools that can be used to assess the efficiency of biodiversity projects (Sarkar et al 2006, Watzold et al. 2006). Although it may not always be possible to value all benefits and costs, economic analysis is becoming an increasingly relevant source of information to governments, donors, legislators and the general public who want to understand the return on investment of the limited resources that have been devoted to conservation projects (Naidoo and Ricketts 2006, Arrow et al. 1996). This manuscript addresses several important issues related to the assignment of benefits and costs of wildlife biodiversity conservation projects.

All of the methods of measuring costs and benefits described require data, meaning that prior to the initiation of a project, managers should focus on data collection methodologies that can enaable the appropriate analyses at the conclusion of the study. The collection of survey data in particular is frequently prohibitively expensive and time consuming, so if a survey is going to be conducted at the termination of a project, sufficient time and resources must be devoted in order to ensure completion of the analysis. Regional economic analysis is very attractive to stakeholders however, it requires estimates of changes in variables like tourism related to the conservation of the target species of the project. This will likely require considerable front end data collection as well as collection of information at the end of the project. Additionally, familiarity with these types of models is necessary to ensure that quality outputs are derived.

Capturing accurate costs is crucial to estimating project efficiency. The use of geo-spatial mapping technologies has allowed for significant improvements to the estimation of opportunity costs in terms of land values. Additionally, the use of regional economic modeling allows for the calculation of possible value added of alternate land uses such as agricultural production. The combination of these methodologies allows for the most accurate estimation available of the opportunity costs associated with designating land into conservation status for the protection of wildlife.

Calculating benefits is difficult, however utilizing the methodologies described provides a framework from which wildlife conservation programs can derive estimates of value. Not only have significant improvements been made in the ability to capture benefits, but a number of studies have been conducted which allows for the potential of using the benefit-transfer methodology to estimate value. Benefits derived from REA can be used in the overall calculation of benefits or net benefits but cannot be used in the determination of benefit-cost ratios.

Problems exist with all the methodologies, but combining methodologies reduces the uncertainty surrounding any particular value. For example, conducting a survey to determine a WTP of a conserved species and using a benefit-transfer value from another WTP survey is better than either on its own. Several values for conservation species will allow for a range of benefit-cost ratios to be calculated and lend an important degree of flexibility to the analysis. The conservation of all species of concern is important and there are many ways to measure cost effectiveness of conservation efforts. Some of the more common methods have been discussed in this manuscript. Likely, the most important point about the economics of biodiversity conservation is that some attempt to assess project efficiency is better than none, because often competing projects are assessing efficiency to convince stakeholders that their project offers the best returns.

Implications for Conservation Project Planning

Wildlife biodiversity conservation projects are becoming necessary to preserve the Earth's diminishing wildlife resources. Increasingly, limited budgets are forcing project planners and funders to select from a variety of project attributes to optimize returns on project investments. Our study highlights key factors that will play a role in guiding project managers and funders to optimal project success.

We find that geography matters in terms of driving costs and realization of benefits. Our findings indicate that when possible, optimal site selection will involve a site that has low alternative use values (e.g., agricultural, recreational, commercial, etc.), high ecosystem service values in its current or improved state (e.g., tourism, natural resource harvest, carbon storage, etc.), adequate size to achieve economies of scale in management efforts and a location removed from potential conflict areas.

In terms of benefit estimation our study suggests that while benefits are difficult to estimate, they are extremely valuable in terms of relaying the importance of overall conservation project impacts. A variety of methods exist to capture benefits of wildlife conservation and incorporating improved methodologies such as regional economic modeling broadens the scope of applicable results to engage a larger audience. If the general public can gain an understanding of the potential gains to local communities resulting from conservation efforts in their region, this will likely have significant influence on project acceptability and success.

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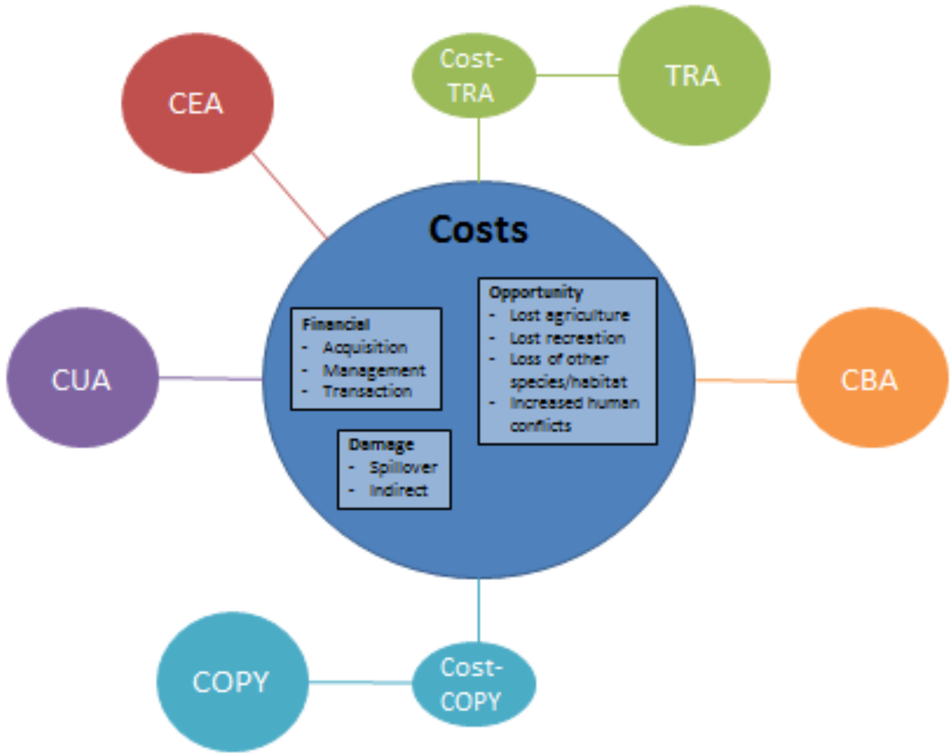

Figure 1

Figure captions

Figure 1. Cost structure associated with biodiversity projects.

Figure 2. Benefit structure associated with biodiversity projects. I did not see Figure 2.